Vertical specialisation indicator based on supply-driven input-output model

著者	Meng Bo, Yamano Norihiko, Webb Colin
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Vertical Specialisation Indicator Based on Supply-Driven Input-Output Model

Bo MENG[1], Norihiko YAMANO[2] and Colin Webb[3]

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Abstract

"Import content of exports", based on Leontief's demand-driven input-output model, has been widely used as an indicator to measure a country's degree of participation in vertical specialisation trade. At a sectoral level, this indicator represents the share of inter-mediates imported by all sectors embodied in a given sector's exported output. However, this indicator only reflects one aspect of vertical specialisation – the demand side. This paper discusses the possibility of using the input-output model developed by Ghosh to measure the vertical specialisation from the perspective of the supply side. At a sector level, the Ghosh type indicator measures the share of imported intermediates used in a sector's production that are subsequently embodied in exports by *all* sectors. We estimate these two indicators of vertical specialisation for 47 selected economies for 1995, 2000, 2005 using the OECD's harmonized input-output database. In addition, the potential biases of both indicators due to the treatment of net withdrawals in inventories, are also discussed.

Keywords: vertical specialisation, Ghosh inverse, supply-driven, input-output

JEL classification: F1

[1] The Institute of Developing Economies – JETRO and OECD (mengbo@ide.go.jp).
[2] Directorate for Science, Technology and Industry, OECD.
[3] Directorate for Science, Technology and Industry, OECD.

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

1. Introduction

The outlook of the world economy has been significantly changed by a rapid globalisation of economic activity during the last two decades. One of the most important features of current globalisation is increasing vertical specialisation (VS) trade. VS trade can be defined as the international trade that occurs when segments or stages in production processes can be rapidly spread or extensively relocated to a range of production sites in multiple countries according to the comparative advantage of each country. The most important factor that has enabled the increase of VS trade is the continuous fall in cross-border trade costs (monetary and non-monetary); improved infrastructure and logistics services; and improved information technology (Hummels 2007, Jacks 2008). With the increasing prevalence of VS trade, more firms in more countries have joined worldwide production networks. As a result, global trade in intermediate goods and services has been steadily growing since the early 1990s[1], and economic interdependence among countries has increased significantly.

As shown in Figures 1 and 2, both export shares (exports / total output) and import shares (intermediate imports / total input) increased between 1995 and 2000 for most economies, and increased again for almost half of the economies between 2000 and 2005. This clearly reflects most economies' increasing tendency to use and provide more international resources (e.g. parts and components). In addition, when looking at Figure 3, the increasing positive relationship between export orientation (export share) and reliance on intermediate imports (import share) can be easily confirmed. These figures provide us with an intuitive image that, between 1995 and 2005, many countries have become deeply involved in international production networks.

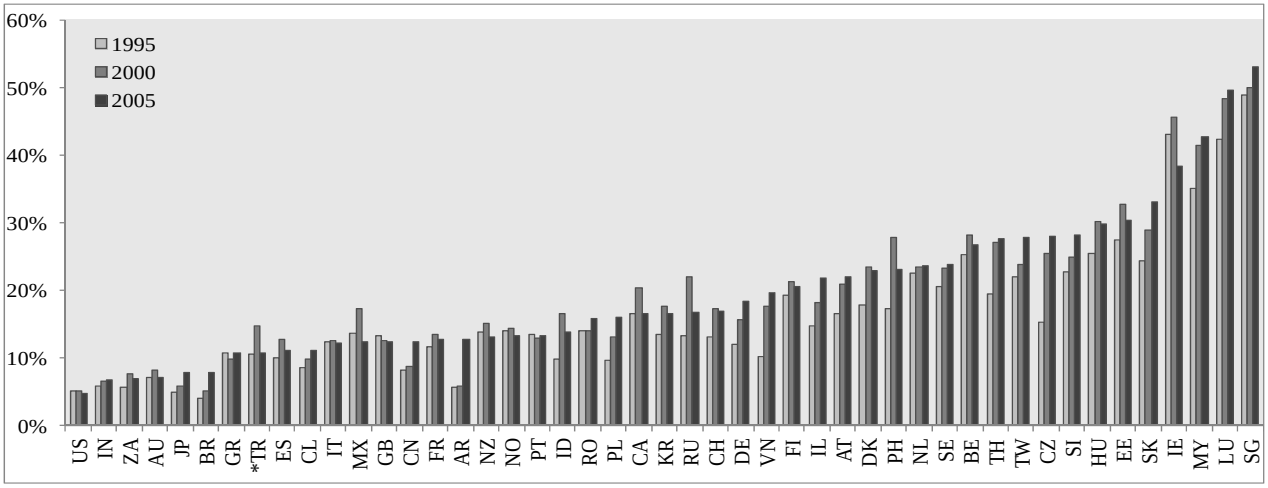
Since statistics describing cross-border activities of multinational enterprises are not readily available in most countries, the magnitude of vertical specialisation trade has often been indirectly measured using non-competitive type national input-output (I-O) tables[2]. In particular, much use has been made of the import content of exports (VS share) indicator proposed by Hummels *et al*. (2001). The empirical advantage of this indicator is that the data requirements are relatively low. In addition, Hummels *et al*. (2001) proposed another indicator (VS1) which represents a country's exports that are used by another country as intermediate inputs for the production of goods for further export.

More recently, these VS indicators have been extended by various studies. For example, Uchida and Inomata (2009) use Asian International I-O Tables from the Institute of Developing Economies (IDE) - JETRO, to separate the VS measure into two parts: a VS_i indicator of exports for intermediate use (parts and components); and a VS_f indicator of exports for final consumption use. They conclude that vertical specialisation has developed rapidly in the Asia-Pacific region, and that China has been the most important hub of the so-called triangular trade (USA - China - Other Asian Economies). They also emphasize that the upstream production process of intermediate goods is relatively "resistant" to the influence of exogenous shocks compared with assembly processes. Following Hummels *et al.* (2001), Yamano *et al.* (2010) propose two alternative demand-driven indicators: capturing the share of vertical specialisation in a particular country relative to world exports (EPE) and the share of re-exported intermediate inputs relative to total intermediate exports supplied by a particular country (REI). Using the harmonized I-O tables of Asian countries, these indicators attempt to explain a position of a specific country in the fragmentation chain as well as the magnitude of participation in the international production network. Koopman et al. (2010) also develop VS related measurements to trace value added embodied in international trade using an international I-O model and bilateral trade statistics.

[1] According to Miroudot *et al.* (2009), trade in intermediate inputs increased between 1995 and 2006 at an average annual growth rate of 6% for goods and 7% for services (in volume terms).

[2] The inter-industry transactions of imported goods and domestically produced goods are explicitly separated in the non-competitive type input-output table.

Figure 1. Exports as a share of total output



Note (*): The middle bar for Turkey is based on its 2002 benchmark I-O data.

Figure 2. Intermediate imports as a share of total input

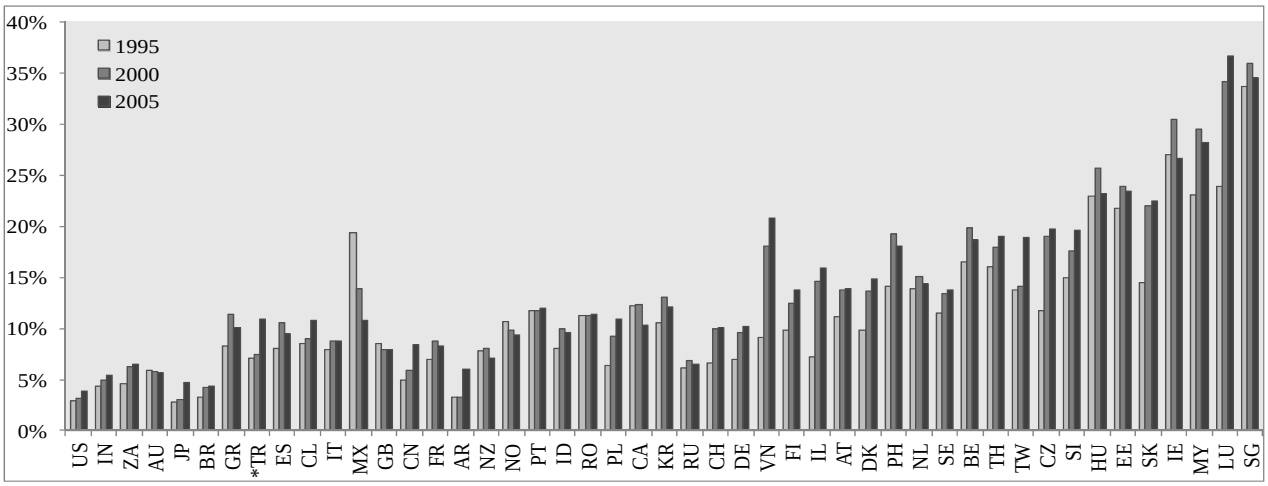
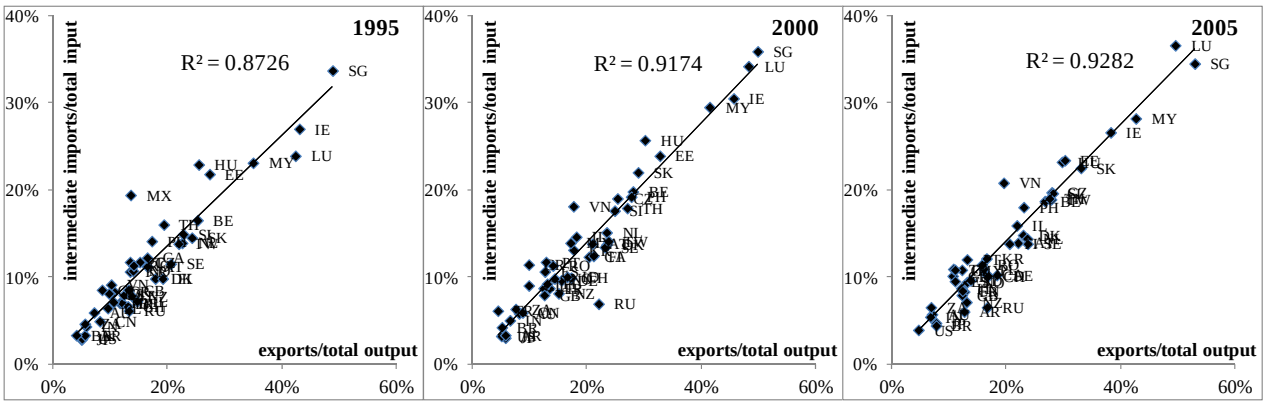


Figure 3 Relationship between export share and import share



Source: OECD Input-Output database, 2010: www.oecd.org/sti/inputoutput

In addition, analysis of vertical specialization has been expanded to focus on the treatment of processing exports i.e. distinguishing between the function of processing exports and non-processing exports (Koopman *et al*., 2008 and Yang *et al*, 2009). Consideration of trade in goods for processing is particularly important in a country with significant exports of goods for processing, since the input structure of the processing oriented sector is greatly different from that of the non-processing exports sector. Using an expanded I-O table for China, in which production is explicitly separated into processing and non-processing sectors, it has been shown that the conventional VS indicator underestimates the degree of vertical specialisation (see Koopman *et al*. (2008) for 1997, 2002 and 2006 and Yang *et al.* (2009) for 2002).

The indicators described above are based on Leontief's I-O model. However, these kinds of indicators only reflect one aspect of vertical specialization, namely the demand-side approach. The purpose of this paper is to discuss the possibility of using Ghosh's I-O model to measure the magnitude of vertical specialization from a different aspect, namely the supply-side.

This paper proceeds as follows: the next section discusses the relationship between the conventional VS indicator and the Ghosh type VS indicator and then shows a cross-country application result of both indicators by using the harmonized OECD I-O database; Section 3 then discusses the potential biases of both indicators caused by the treatment of net withdrawals in inventories. The concluding remarks are given in Section 4.

2. **VS indicators based on single country I-O models**

2.1 The relationship between demand-driven and supply-driven I-O based VS indicators

As mentioned above, most existing VS indicators are based on the demand-driven I-O model. For example, the widely used VS measurement (import contents of export, Hummels *et al*., 2001.) can be rewritten as follows:

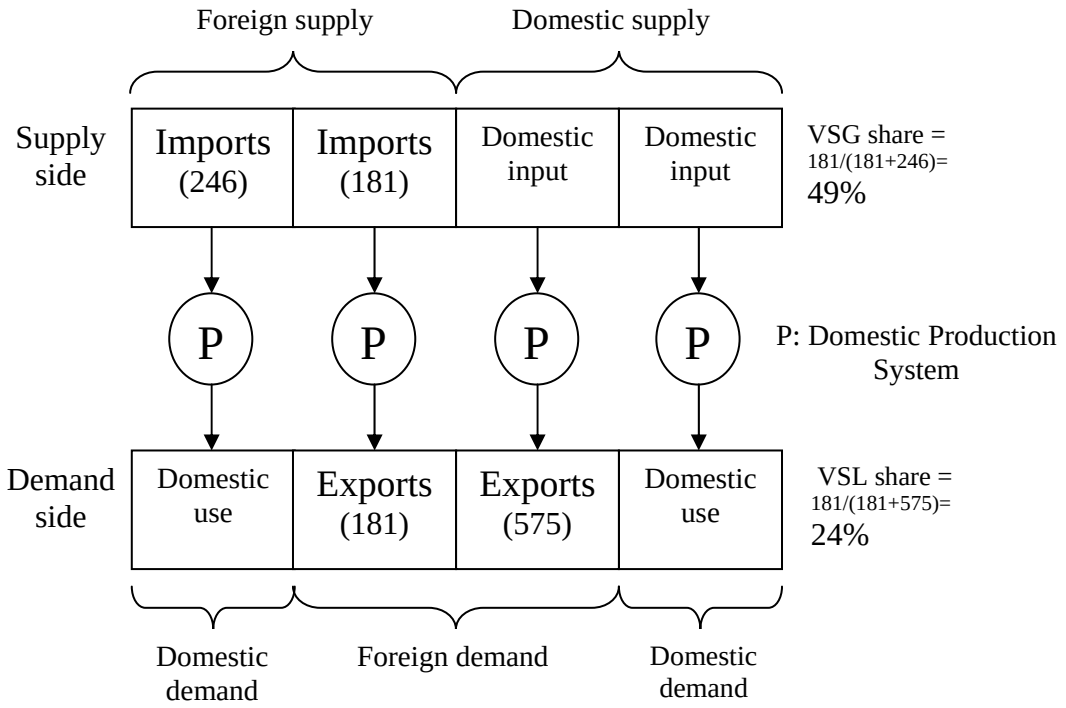
$$VSL = \mathbf{m} \cdot (\mathbf{I}-\mathbf{A_d})^{-1} \cdot \mathbf{EX}, \quad (1)$$

where, **m** is the 1 × n row vector of import coefficients (the share of imported intermediate goods to total input by *n* sectors), $\mathbf{A_d}$ is the domestic input coefficient matrix of n sectors (n × n), **I** is the identity matrix, $(\mathbf{I}-\mathbf{A_d})^{-1}$ is the domestic Leontief inverse matrix, and **EX** is the n × 1 column vector of exports. The VSL measure represents the direct and indirect imports of intermediate goods induced by export demand, often described as the value of imported intermediates *embodied* in a country's exports. VSL can thus be interpreted as a measure of a country's degree of participation in international production networks. This indicator also represents the **backward linkages** in domestic inter-industrial production chains, since it's based on the Leontief inverse.

On the other hand, using a supply-driven I-O model, the **forward linkages** in domestic inter-industrial production chains can be defined by the Ghosh inverse. The demand-driven I-O model is well established in the fields of National Accounts and regional economics. However, the supply-driven model provokes mixed reactions – facing both critical and supporting comments (Mesnard, 2009). Despite the restrictive assumption in the supply-driven model, namely each commodity is sold to each sector in fixed proportions, it has been shown that the model can be interpreted as a price I-O model (Dietzenbacher, 1997). With this interpretation, the two models may be considered as two sides of the same coin, which reflect the dual relationship of demand and supply within the same economic system.

The Ghosh model in a non-competitive type input-output system can be given as

Figure 4 The relationship between VSL and VSG shares at the total economy level (Germany, 2005, billion Euros)



Source: OECD Input-Output database (2010)

$$\mathbf{X} = \mathbf{V} \cdot (\mathbf{I}-\mathbf{B_d})^{-1} + \mathbf{IM} \cdot (\mathbf{I}-\mathbf{B_d})^{-1}, \quad (2)$$

where, **X** is the output vector (1 × n), **V** is the row vector (1 × n) of total primary domestic inputs (i.e. value added), **IM** is the row vector (1 × n) of imported intermediates, $\mathbf{B_d}$ is the domestic allocation coefficient matrix (n × n), $(\mathbf{I}- \mathbf{B_d})^{-1}$ is the domestic Ghosh inverse matrix.

Multiplying the column vector of export coefficients **e** (the share of exports to total output) to the above equation yields

$$\mathbf{u} \cdot \mathbf{EX} = \mathbf{V} \cdot (\mathbf{I}-\mathbf{B_d})^{-1}\mathbf{e} + \mathbf{IM} \cdot (\mathbf{I}-\mathbf{B_d})^{-1}\mathbf{e}, \quad (3)$$

where, **u** is a 1 × n vector of 1's. The first term of right-hand side of equation (3) represents the exports induced by the domestic primary inputs (e.g. labour and capital supply) and the second term is the exports induced by the imported intermediates which is defined as the Ghosh-type VS indicator (VSG) in the paper.

Since the following relationship holds (Miller and Blair, 2009):

$$(\mathbf{I}-\mathbf{A_d})^{-1} = \underline{\mathbf{X}} \cdot (\mathbf{I}-\mathbf{B_d})^{-1} \cdot \underline{\mathbf{X}}^{-1}. \quad (4)$$

The national total of VSL and VSG can be shown to be equal:

$$\mathbf{IM} \cdot (\mathbf{I}-\mathbf{B_d})^{-1} \cdot \mathbf{e} = \mathbf{m} \cdot (\mathbf{I}-\mathbf{A_d})^{-1} \cdot \mathbf{EX}, \quad (5)$$

where, $\underline{\mathbf{X}}$ is the n × n diagonal matrix with non-zero elements of output by sector. Although, VSL equals VSG at the total economy level, the relative magnitude of vertical specialisation can be respectively measured by VSL share and VSG share as shown below:

VSL share = VSL / $\mathbf{u} \cdot \mathbf{EX}$; (6)
VSG share = VSG / $\mathbf{IM} \cdot \mathbf{u}^t$. (7)

The relationship between VSL and VSG shares can be easily explained by Figure 4. Based on equation (5), it's easy to see that the total intermediate imports induced by export demand (181+575=756) is 181, and the total exports induced by the supply of intermediate imports (246+181=427) is also 181. However, the VSL share and VSG share are respectively 24% and 49%. If we just consider the VSL share, one would conclude that this country's degree of participation in global production networks is not so high. However, with the VSG share we could say that the country has a relatively high participation since half the value of its intermediate imports is exported to other countries.

Although, VSL and VSG are the same at the total economy level, at the individual sector level, they may be very different. VSL and VSG at sectoral level can be defined as follows:

$VSL_i = \mathbf{m}(\mathbf{I}-\mathbf{A_d})^{-1}\mathbf{EX}_i$; (8)
$VSG_i = \mathbf{IM}_i(\mathbf{I}-\mathbf{G_d})^{-1}\mathbf{e}$, (9)

where, $\mathbf{EX}_i$ is an n × 1 column vector constructed by the export of sector (commodity) i and zero elements for the other sectors (commodities). $\mathbf{IM}_i$ is a row vector constructed by the intermediate imports used by sector i and zero elements for the other sectors. Thus, the VSL_i measure shows the embodied imported intermediates in all exports of an individual good (sector) i; while the VSG_i measure represents the value of intermediate imports used by sector i that end up in a country's total exports. These two different indicators make it possible to measure the vertical specialisation for a specific sector from different perspectives.

The VSL and VSG shares are defined as the following forms:

VSL share for sector i = VSL_i / $\mathbf{u}\,\mathbf{EX}_i$, (10)
VSG share for sector i = VSG_i / $\mathbf{IM}_i\,\mathbf{u}^t$. (11)

In the measurement of VSL share, exports are considered as exogenous demand by the rest of the world. Thus, the VSL share is known as a demand-driven I-O based global value chain indicator. On the other hand, imports are considered as exogenous in the measurement of VSG share, namely the supply from the rest of the world. Thus, we can consider the VSG share as a supply-driven I-O based indicator. If much more imported intermediates used by a specific sector are bound up in exports, the value of VSG share becomes large. Therefore, the VSG share eventually represents the participation degree and position of a country's specific sector in the global production network.

2.2 Numerical examples

These two different vertical specialization indicators (VSL and VSG) are calculated for 47 economies (32 OECD countries and 15 non-OECD countries) and 37 industries using the OECD non-competitive type harmonized input-output database (see Appendix). The details of the country coverage and industry classification are available at www.oecd.org/sti/inputoutput. In order to increase the number of comparable target countries, the benchmark I-O tables are updated / interpolated using IDE - JETRO's Asian International I-O Table (1995) and other industry-based economic data sources such as National Accounts from national statistical institutes, the World Bank and OECD's Structural Analysis (STAN) and Bilateral Trade Databases.

Figure 5 VSL and VSG shares at the total economy level (2005)

Figure 6 VSL and VSG shares for Office, accounting & computing machinery (2005)

Figure 5 shows estimates of national VSL and VSG shares for 2005 based on the OECD I-O data. At this level, there is a relatively strong correlation (0.84) between the two indicators. This is not unexpected since equations (5), (6) and (7), show that the difference between VSL and VSG shares only depends on the difference between the values of total intermediate imports and total exports, which themselves are strongly correlated (see Figure 3). Despite this correlation, a large variation can still be observed for some countries. For example, Sweden (SE), Canada (CA), Spain (ES) and Chile (CL) have similar VSL shares (embodied imports in exports are about 30%) but their VSG shares are very different: intermediate imports end up their exports for Sweden is about 57%, for Canada about 51%, for Spain about 39%, while for Chile, the value is 35%. This suggests that these countries have similar degrees of participation in global production networks when we measure their VS magnitude from the demand side, but from supply side, their VS degrees are different.

Figure 6 compares VSL and VSG shares for the *"Office, accounting and computing machinery sector"* (ISIC 30) for 2005. They are not significantly correlated (the coefficient of correlation = 0.47) and showing more variability compared with the calculations at the total economy level (Figure 5). For example, the VSL shares for China and Brazil are similar (close to 45%) while the VSG shares are significantly different. In China, 56% (by value) of intermediates imported by the office machinery sector are subsequently re-exported to other countries; while for Brazil, only 13% of intermediate goods imported by its office machinery sector end up its exports. This clearly reflects the difference degrees of participation in global production chains for the office machinery sector in China and Brazil from a supply-side viewpoint.

The results for France and Korea also indicate differing characteristics of production and supply chains. While, the import contents of exports (VSL share) are significantly different, the shares of imported intermediates subsequently embodied in exports are similar for both countries' office machinery sectors. This can be interpreted as the production structure of Korea's industry requiring more imported intermediates to produce a unit of office machinery (for both domestic use and export).

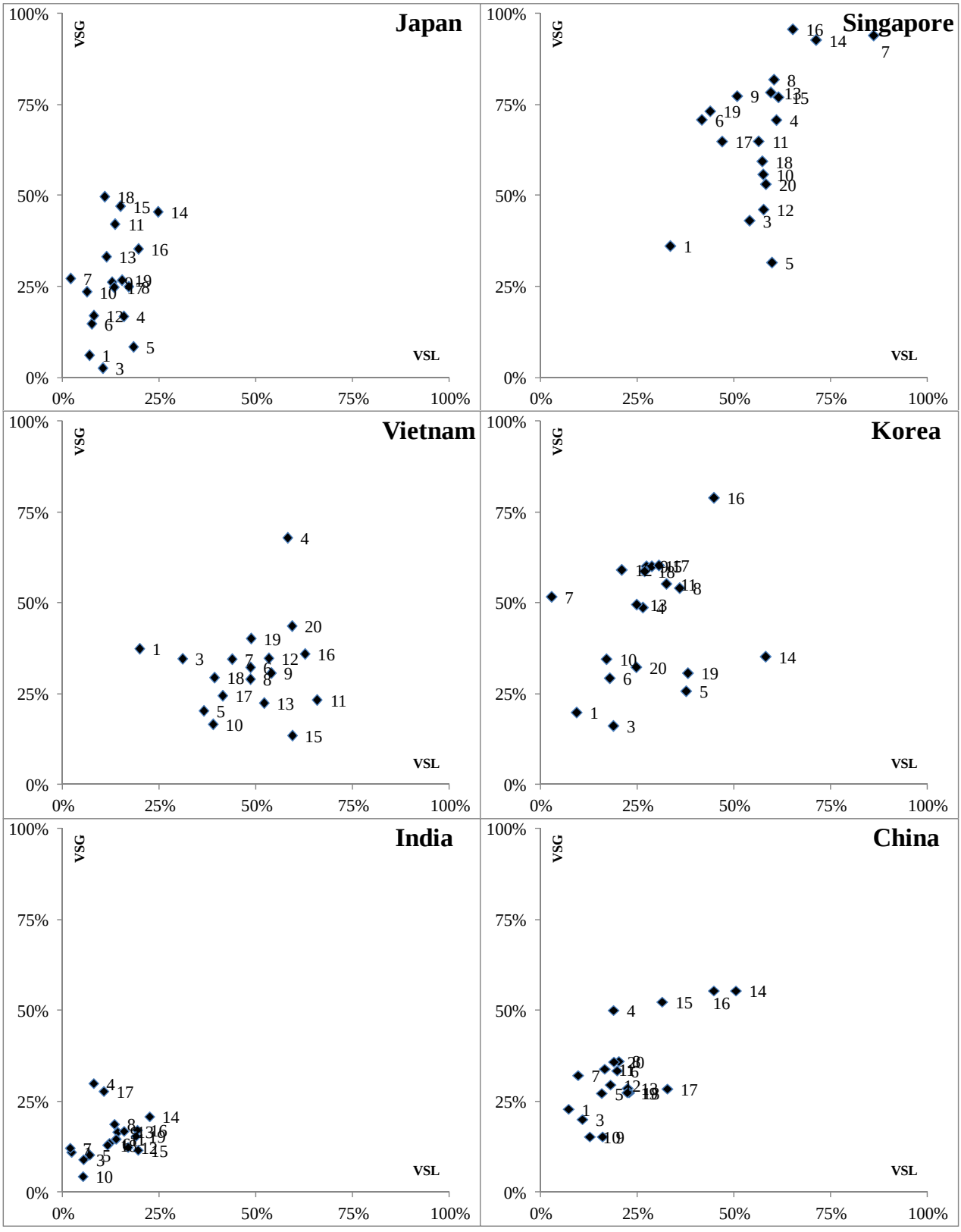
In order to investigate VS in detail, we plot the sectoral VSL and VSG shares (excluding Mining, Utility and Services sectors) for selected Asian countries (Figure 7) and for some American and European countries (Figure 8). The main features can be summarized as follows:

(1) there is a large variation in the distribution pattern of sectoral VS across countries. For example, most sectors of Japan locate horizontally with low VSL share and relatively lower VSG share. In contrary, Singapore's sectors also horizontally distribute, but their VSL and VSG shares are very high. Comparing India and Korea, a clear difference can be found. For India both the VSL and VSG shares for most sectors are lower than 25%, while for Korea, most sectors have higher VSL and VSG shares (greater than 25%) and show higher variability. In addition, Vietnam has similar VSG shares to China, while its VSL shares are notably higher for most sectors. Referring to the distribution pattern shown in Figure 7 and 8, countries can be roughly classified into the following four types:

(2) At the sectoral level, there are some common features in VSL and VSG shares. For example, in most countries, the VSL and VSG shares of sector 1 (*Agriculture, hunting, forestry and fishing*), 3 (*Food products, beverages and tobacco*) and 5 (*Wood and products of wood and cork*) are relatively low. This is because the production of goods in these sectors mainly depends on domestic inputs of resources (raw materials) rather than intermediate imports. On the other hand, sector 14 (*Office, accounting & computing machinery*) in most countries has both higher VSL and VSG levels. This clearly reflects the fact that computing machinery is one of the most internationally fragmented products, and most countries are involved in its international production networks.

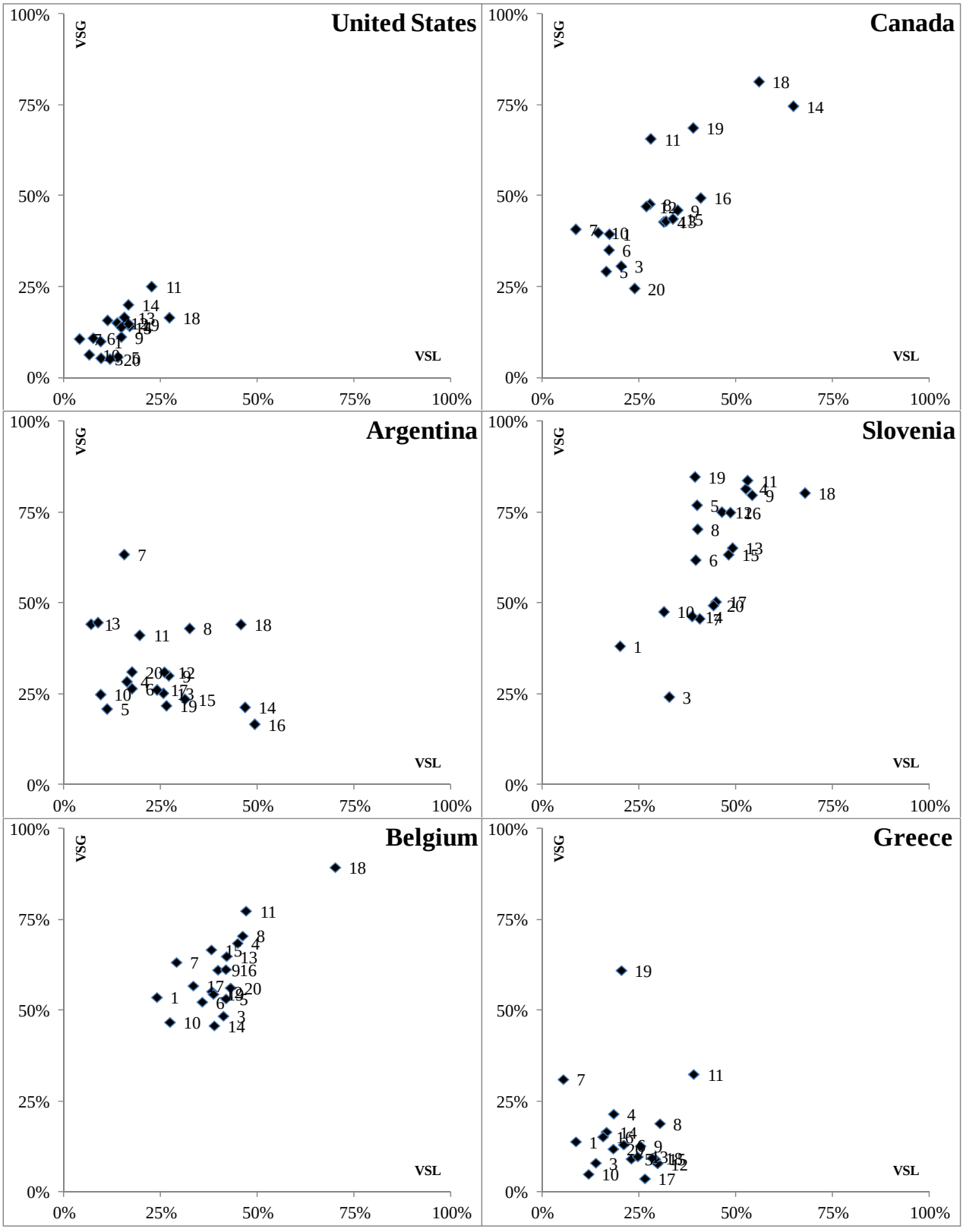
(3) Leading VS sectors vary across countries. While *Office, accounting & computing machinery* dominates for many countries, in Singapore sectors 16 (*Radio, television & communication equipment*) and 7 (*Coke,*

Figure 7 Sectoral VSL and VSG shares for selected Asian countries (2005)



Note: See Appendix for sector descriptions

Figure 8 Sectoral VSL and VSG shares for selected American and European countries (2005)



Note: See Appendix for sector descriptions.

Figure 9 VSL share of the *Office, accounting & computing machinery* sector (1995, 2000, and 2005)

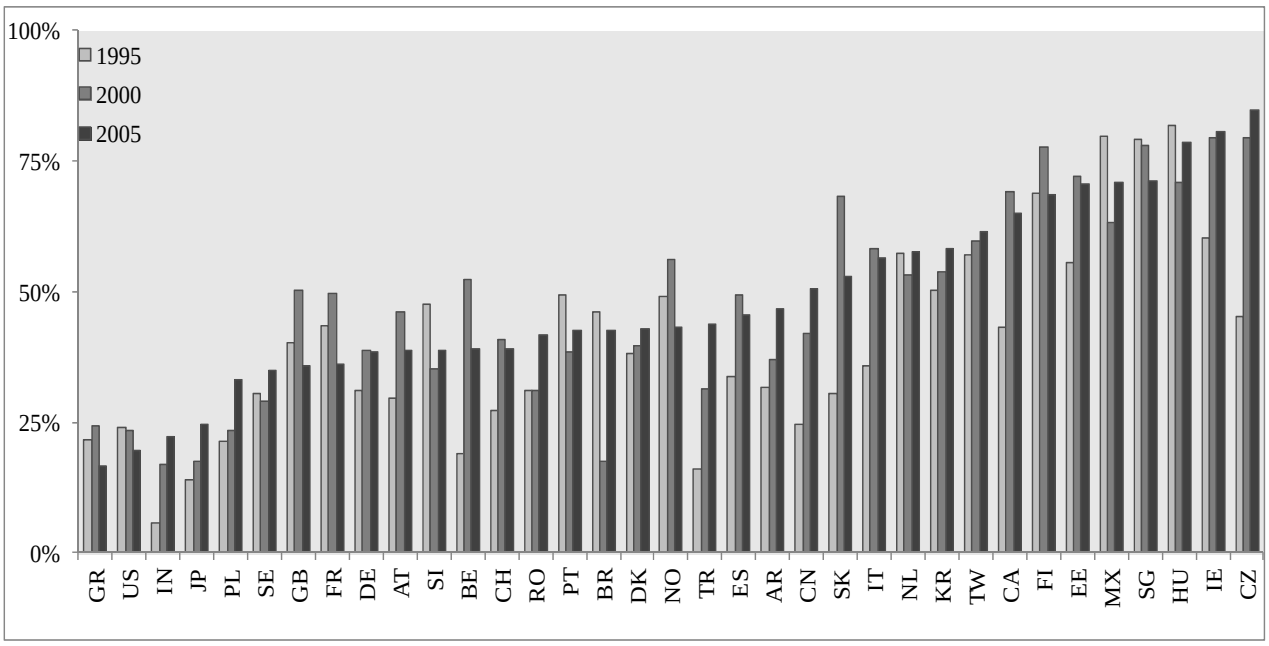
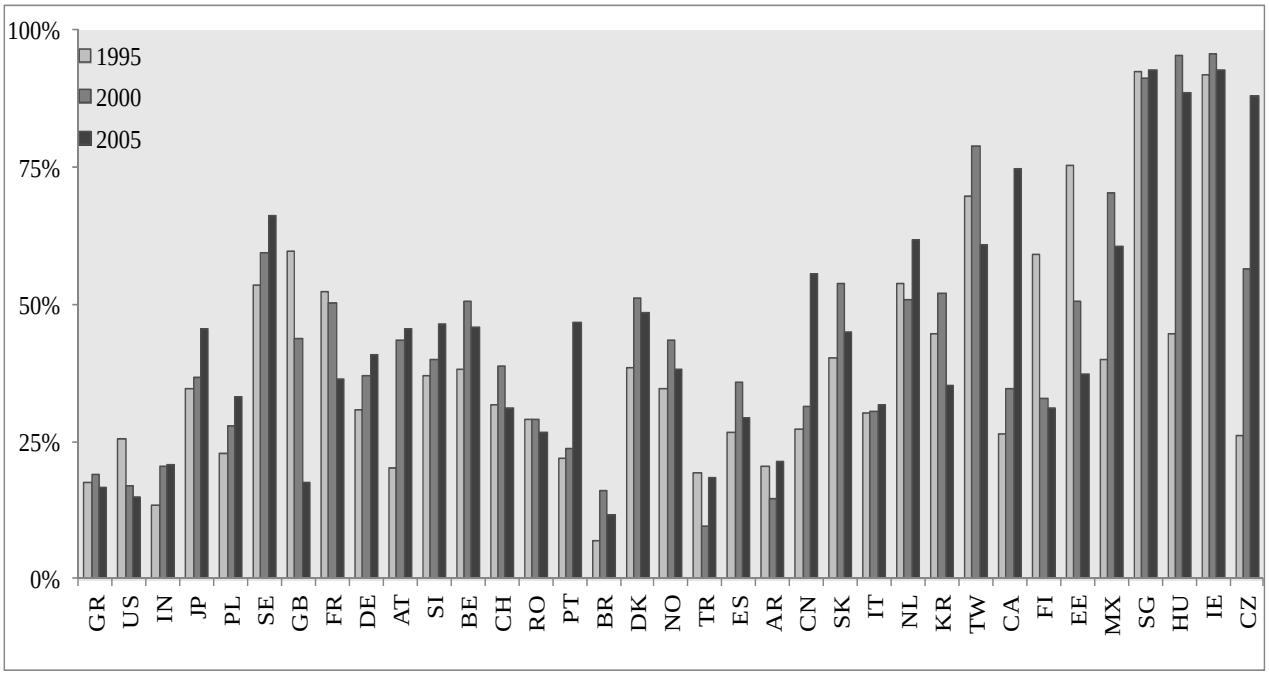


Figure 10 VSG share of the *Office, accounting & computing machinery* sector (1995, 2000, and 2005)



refined petroleum products and nuclear fuel) play a major role; for Vietnam, sector 4 (*Textiles, textile products, leather and footwear*); and for Korea, sector 16; Sector 18 (*Motor vehicles, trailers & semi-trailers*) stands out for the United States, Canada, Argentina, Slovenia and Belgium; for Greece, sectors 11 and 19 (*Other transport equipment*) take the lead; while for China, sector 4, 15 (*Electrical machinery & apparatus, nec.*), 16 are the main leading VS sectors. This reflects the nature of international divisions of production.

As mentioned before, the *Office, accounting and computing machinery* sector can be considered as a leading VS sector because of its high VSL and VSG shares in most countries. Here, we focus on this sector to investigate the evolution in its vertical specialisation trade. Figure 9 shows the VSL share of this sector for the years 1995, 2000 and 2005. Some outstanding features can be easily found: (1) the VSL share for more than half economies increased between 1995 and 2000; (2) some economies (India, Japan, Poland, Romania, Denmark, Argentina, Italy, Canada, and Czech Republic) maintained this trend between 2000 and 2005; (3) a dramatic increase of VSL share between 1995 and 2000 can be found for some countries – such as India, Belgium, Turkey and Czech Republic; (4) For many European countries' VSL shares seemed to have peaked around 2000 and then declined.

When looking at the situation of VSG share (Figure 10), it's easy to see that (1) more than half of the economies enhanced their VSG shares between 1995 and 2000; (2) for some countries such as India, Japan, Poland, Sweden, Austria, Slovenia, Portugal, Canada and Czech Republic, the VSG share increased again between 2000 and 2005; (3) dramatic increases can be found for China, Portugal, Canada and Czech Republic; (4) while on the other hand, a continuous decline in VSG share is evident for United kingdom, France, Finland and Estonia during the period of 1995 – 2005.

There are several explanations for the apparent changing patterns of sectoral VSL and VSG shares across country. The first is the bursting of dot-com bubble happened around 2000, which had a great impact on the production of IT related sectors. This may explain why VSL and VSG shares for some countries peaked in 2000 and then sharply declined. The second reason is that many multinational enterprises increased their local procurement ratio for cutting trade costs. This may directly affect the VSL share. In addition, after the dot-com bubble burst, a worldwide re-organisation in the IT industry took place and gave some countries a chance to specialize in the production of certain IT related goods. This also supports the observation that the VSG share in some developing countries grew up rapidly after 2000. In addition, more general changes in export structures and domestic production networks may also influence the value of VS indicators.

3. Potential biases in the existing VS indicators

Harmonised non-competitive type national I-O tables allow comparisons to be made of the VSL and VSG indicators across countries. However, it should be noted that the exports in trade statistics and I-O tables include not only current-year products but also goods produced in previous years. In an extreme case the exports value may be larger than total output. For example, *exports/output* = 116%, *change in inventory/exports* = -17.8% for *Medical, precision and optical instruments* sector of Indonesia 1995; *export/output* = 248%, *change in inventory/exports* = 63.1% for *Basic metals* sector of Estonia 2000. This clearly implies that without adjusting the export figure by the change in inventory, the estimated sectoral VSL and VSG shares may be biased to some extent.

The measurement bias of both indicators are investigated using the following preliminary treatment of exports under the assumption that a **negative** change[3] in inventories is distributed across final demand components in an I-O table. If possible, a more preferable adjustment would be done using detailed survey-based information.[4]

[3] A positive change in inventories is not considered as an adjustment target, since it does not affect the export of current year.

[4] For the sake of simplicity, the change in inventory is normally considered one part of "capital formation". In fact, the complete adjustment requires splitting the change in inventory to the whole row of an I-O table including intermediate inputs and final demands. However, the fact is that only for a few countries, the change in inventory is separated by different final demand item in their I-O tables. Furthermore, there is not any published information about how many intermediate inputs are from inventories. In addition, most published information about inventory is a net

Adjusted exports (EX_i^{adj}) = exports – net withdrawals of inventories × (exports as a share of total final demands).

The adjusted VSL_i and VSG_i are then given as

$$VSL_i^{adj} = \mathbf{m}\,(\mathbf{I}-\mathbf{A_d})^{-1}\,\mathbf{EX}_i^{adj}, \quad (10)$$

$$VSG_i^{adj} = \mathbf{IM}_i\,(\mathbf{I}-\mathbf{G_d})^{-1}\,\mathbf{e}^{adj}, \quad (11)$$

where, $\mathbf{e}^{adj}$ is the n × 1 column vector constructed by adjusted export shares. Obviously, when the export item is adjusted, the figure of VSG_i should be affected much more than the figure of VSL_i, since export shares ($\mathbf{e}^{adj}$) for all sectors in the VSG_i are adjusted, but in the case of VSL_i, just the export of sector i ($\mathbf{EX}_i^{adj}$) is adjusted.

Figure 11 shows the bias (as the absolute percentage difference[5]) between the VSL_i share and the VSL_i^{adj} share for low-technology and high-technology manufacturing goods estimated from the OECD I-O database. The bias of VSL_i share for low-technology goods in most countries is larger than for high-technology goods. This may be due to a variety of reasons. For example, the inventory cost of low-technology goods may be lower and therefore adjusted more frequently; in addition, the price changes for some low-technology goods, like raw materials may be more volatile than those for most high-technology goods, motivating firms, for example, to maintain some inventories as protection against fluctuating price changes; furthermore, just-in-time production systems, which minimise inventories, may be another reason. From Figure 2, it's also easy to see that the bias of the VSL share for low-technology goods in some countries, like India, Mexico and United States are relatively higher. If we trace more detailed sector classification, such bias becomes much larger.

Figure 12 shows the bias between VSG_i and VSG_i^{adj} shares. Comparing with Figure 2, the whole level of biases for VSG_i share is higher than it for VSL_i share. Especially, for the case of Mexico, the bias for low-technology goods is about 9%. It's not so surprising, as mentioned above, in the measure of VSL_i^{adj} share, the adjusted export is just for one sector, but in VSG_i^{adj} share, the export rates for all sectors are adjusted by changes in inventories. This fact implies that the use of the VSG indicator may be sensitive to the treatment of changes in inventories.

4. Conclusion

This short paper discussed the possibility of using Ghosh's I-O framework to measure the degree of vertical specialisation trade from the perspective of the supply-side. The results show that at a sector level the supply-driven I-O based vertical specialization indictor can provide a different perspective for the measurement of international fragmentation. In other words, Leontief's demand-driven model based vertical specialisation indicator represents the embodied intermediate imports of various commodities in an individual exporting good; the Ghosh's supply-driven model based indicator shows how much the value of imported intermediates used as inputs of a certain sector is embodied in various exported goods. The empirical results using the OECD I-O database indicate that the supply-driven I-O based indicator should be considered an useful and complementary measure of vertical specialisation. However, the supply driven indicator has greater potential measurement biases due to changes in inventory in the annual National Accounts.

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value rather than separated gross value by different item, like inventory additions and inventory withdrawals in Canada's 2000 I-O table.

[5] The bias of VSL measurement is defined as $|(VSL^{adj}\text{ share}/VSL\text{ share})-1|$.

Figure 11 The potential bias of sectoral VSL share

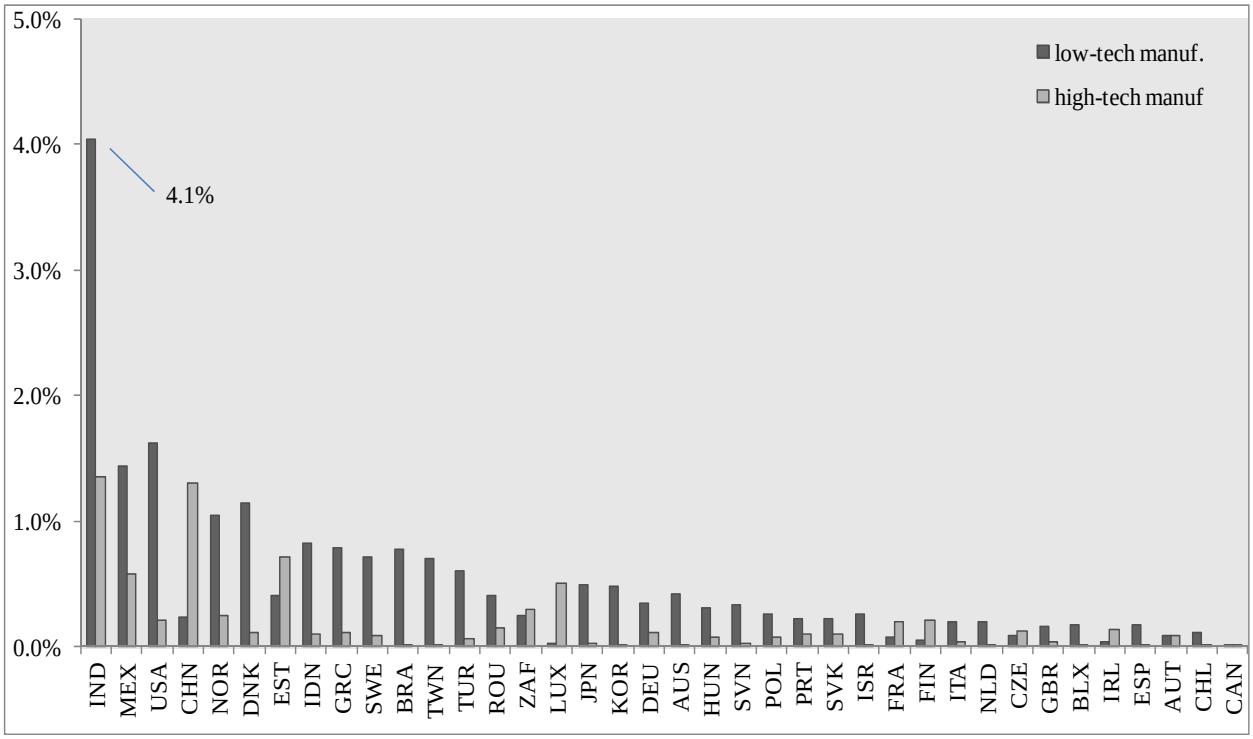
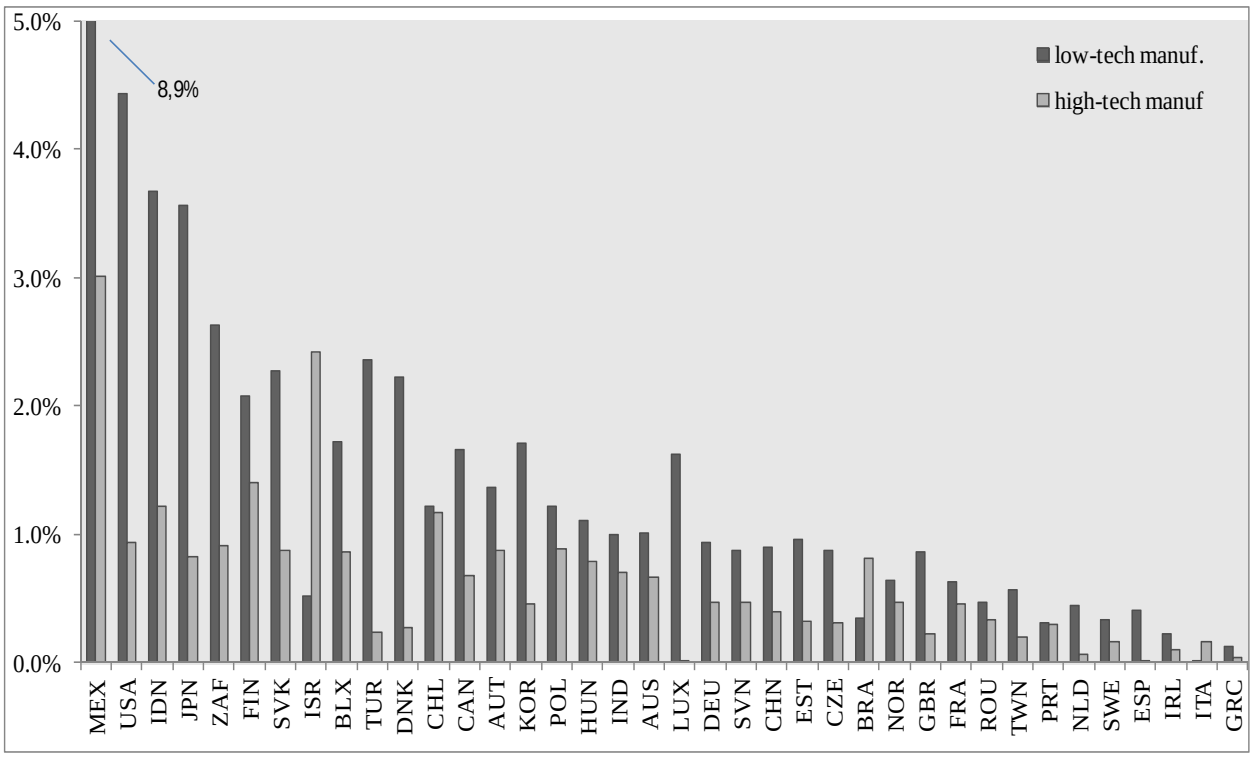


Figure 12 The potential bias of sectoral VSG share



References

Dietzenbacher, E. (1997), "On the relationship between the supply-driven and the demand-driven input-output model", *Environment and Planning* A, 21, 11, pp. 1533-1539.

Hummels, D. (2007), "Transportation costs and international trade in the Second Era of Globalization", *Journal of Exonomic Perspectives*, 21(3), pp. 131-154.

Hummels, D., Ishii, J. and Yi, K.-M. (2001), "The nature and growth of vertical specialization in world trade". *Journal of International Economics*, 54(1), pp. 75 - 96.

Koopman, R., Z. Wang and S.J. Wei (2008), "How much of Chinese exports is really made in China? Assessing domestic value-added when processing trade is pervasive", *NBER Working Paper no. 14109:* www.nber.org/papers/w14109

Koopman, R., W. Powers, Z. Wang and S.J. Wei (2010), "Give credit where credit is due: Tracing value added in global production chains", *NBER Working Paper no. 16426:* www.nber.org/papers/w16426

Mesnard, L.D. (2009), "Is the Ghosh model interesting?", *Journal of Regional Science*, 49(2), pp. 361-372.

Miroudot, S., R. Lanz and A. Ragoussis (2009), "Trade in intermediate goods and services", *OECD Trade Policy Working Paper*, 93:
www.oecd-ilibrary.org/trade/oecd-trade-policy-working-papers_18166873

Uchida, Y. and S. Inomata (2009), "Vertical Specialization in the Time of the Economic Crisis", in Inomata S. and Y. Uchida (eds), *Asia Beyond the Crisis: Visions from International Input-Output Analyses*, IDE Spot Survey 31, pp. 70-83.

Yamano, N., B. Meng and K. Fukasaku (2010), "Fragmentation and changes in the Asian trade network", *ERIA Research Brief.*

Yang, C.H., E. Dietzenbacher, J.S. Pei and X.K. Chen (2009) "The bias in measuring vertical specialization", *Paper presented at the 17th International Input-Output Association Conference*.

Appendix 1 Country or region code

ISO3166	Name	ISO3166	Name	ISO3166	Name	ISO3166	Name
AR	Argentina	DE	Germany	NL	Netherlands	CH	Switzerland
AU	Australia	GR	Greece	NZ	New Zealand	TH	Thailand
AT	Austria	HU	Hungary	NO	Norway	TR	Turkey
BE	Belgium	IS	Iceland	PH	Philippines	GB	United Kingdom
BR	Brazil	IN	India	PL	Poland	US	United States
CA	Canada	ID	Indonesia	PT	Portugal	VN	Viet Nam
CL	Chile	IE	Ireland	RO	Romania		
CN	China	IL	Israel	RU	Russian Federation		
TW	Chinese Taipei	IT	Italy	SG	Singapore		
CZ	Czech Republic	JP	Japan	SK	Slovak Republic		
DK	Denmark	KR	Korea	SI	Slovenia		
EE	Estonia	LU	Luxembourg	ZA	South Africa		
FI	Finland	MY	Malaysia	ES	Spain		
FR	France	MX	Mexico	SE	Sweden		

Appendix 2 Sector classification

	Sectors	ISIC Rev.3
1	Agriculture, hunting, forestry and fishing	01+02+05
2	Mining and quarrying	10+11+12+13+14
3	Food products, beverages and tobacco	15+16
4	Textiles, textile products, leather and footwear	17+18+19
5	Wood and products of wood and cork	20
6	Pulp, paper, paper products, printing and publishing	21+22
7	Coke, refined petroleum products and nuclear fuel	23
8	Chemicals	24
9	Rubber & plastics products	25
10	Other non-metallic mineral products	26
11	Basic metals	27
12	Fabricated metal products, except machinery & equipment	28
13	Machinery & equipment, nec	29
14	Office, accounting & computing machinery	30
15	Electrical machinery & apparatus, nec	31
16	Radio, television & communication equipment	32
17	Medical, precision & optical instruments	33
18	Motor vehicles, trailers & semi-trailers	34
19	Other transport equipment	35
20	Manufacturing nec; recycling (include Furniture)	36-37
21	Utility	40-41
22	Construction	45
23	Wholesale & retail trade; repairs	50-52
24	Hotels & restaurants	55
25	Transport and storage	60-63
26	Post & telecommunications	64
27	Finance & insurance	65-67
28	Real estate activities	70
29	Renting of machinery & equipment	71
30	Computer & related activities	72
31	Research & development	73
32	Other Business Activities	74
33	Public admin. & defence; compulsory social security	75
34	Education	80
35	Health & social work	85
36	Other community, social & personal services	90-93
37	Private households with employed persons	95-99